Amendments to the Specification:

In the SUMMARY OF THE INVENTION, replace the first and seconf full paragraph beginning at page 4 with the following amended paragraph:

The basic aspects of a mechanism to linearly control the capacitance of a variable capacitor in a linear mode through a tuning voltage are described in a related patent application. This related patent application, which is entitled "High Q linear controlled variable capacitor" (~~Document Nr. DS03-005A~~US Patent Application, Serial No. 10/764920, filed Jan. 26, 2004), is hereby incorporated by reference.

In accordance with the objectives of this invention, a circuit to implement a voltage controlled variable capacitor, operating in a linear mode and maintaining High Q-Factor is achieved. The invention disclosed in the referenced ~~document DS03-005A~~ patent application (US Serial No. 10/764920) added circuits and methods to linearize the capacitance change and to minimize the effect of parasitic resistance in the capacitor switching elements, which would degrade Q-factor. The herewith disclosed invention further implements a translinear amplifier and adds additional circuits to further reduce the effect of parasitic resistance and of temperature deviation.

Please add the following paragraph, before the first full paragraph beginning at page 5.

As described in US Patent Application, Serial No. 10/764920, within a set of small capacitors, one capacitor after the other is switched in parallel to change the total. To achieve a linear capacitance change, said capacitors are not switched on one by one in digital steps, however each capacitor is switched on partially in a sliding operation, starting at low value (0 % of its capacitance) and ending with the fully switched on capacitor (100 % of its capacitance). To achieve said sliding switch

operation, a typical implementation uses FET-transistors, one per capacitor. The switching operation of such FET-transistor can be divided into three phases: the fully-switched-off phase (RDS is very high), a steady ramp-up/ramp-down phase or steady transition phase and the fully-switched-on phase (RDS is very low). By thoroughly controlling such switching device within said steady ramp-up/ramp-down phase, the capacitor in series with said switching device is effectively switched in parallel with a well-controlled proportion between 0 % and 100 %.

Please replace the first full paragraph beginning at page 5 with the following amended paragraph:

One key point to obtain highest possible Q-factor is to have at any time only one transistor in the ~~active operating mode~~steady transition phase, i.e. RDSon–change-mode; all other transistors are either fully switched on or fully switched off.

Please replace the forth paragraph beginning at page 5 with the following amended paragraph:

While the switching transistor is kept within its ~~active switching mode~~ steady transition phase (RDS changing mode) the resistance of the transistor linearly follows the input difference of said translinear amplifier. As said translinear amplifier can operate at different absolute voltage levels at their input and output, the resulting level shifting operation is best suitable for said switching transistor's operation.

Please replace the first paragraph beginning at page 6 with the following amended paragraph:

Additional circuit elements, described in the ~~companion disclosure Document DS03-006~~ related US Patent Application, Serial No. 10/676919, filed Oct. 1, 2003 and titled "Translinear Amplifier", implementent~~ing~~ a signal-limiting function and provide a signal

to sharply cut off said translinear amplifier's linear operation, once the defined linear operating range is exceeded at the negative end of said linear operating range; and to sharply limit said translinear amplifier's linear operation, once the linear operating range is exceeded at the positive end of said linear operating range. The circuit of said signal limiting function then overdrives said switching transistor either into ~~its fully-on state~~deep saturation (RDSon going to 0) or overdrives it into its ~~fully~~extreme -off state (RDSoff going very high) when said switching device is outside its ~~dedicated active working area~~ desired steady transition phase.

Please replace the third paragraph beginning at page 6 with the following amended paragraph:

The total concept according to the proposed invention is shown in **Fig. 6**. One key point of the invention is the implementation of a signal-limiting function at both ends of the ~~active switch operating area~~ steady ramp-up/ramp-down phase. Once the signal controlling the switching device leaves the ~~dedicated active area~~ steady transition phase, the signal condition is changed abrupt. **Fig. 7** visualizes this effect. The purpose is to drive said switching device to a fully-on state, when said switching device is outside its ~~dedicated active working area~~ steady transition phase on the lower resistance side (low RDSon) and to drive said switching device to a fully-off status, when said switching device is beyond its ~~dedicated active working area~~ steady transition phase on the higher resistance side(high RDSon).

Please replace the third paragraph beginning at page 7 with the following amended paragraph:

The amplifier primarily generating the control signal for the switching devices is, according to the invention, a translinear amplifier, as described in patent application, US

Serial No. 10/676919, filed Oct. 1, 2003. In addition, a signal-limiting function, which is designed to drive said switching device to a fully-on status, when said switching device is outside its ~~dedicated active working area~~ steady transition phase on the lower resistance side (low RDSon) or to drive said switching device to a fully-~~on~~ff status, when said switching device is outside its ~~dedicated active working area~~steady transition phase on the ~~lower~~ higher resistance side (high RDSon), can be implemented. Such signal-limiting function could, according to the invention, be implemented within the translinear amplifier. It could however be implemented as separate circuit as well.

Please replace the first and second paragraphs beginning at page 8 with the following two amended paragraphs:

Furthermore, the temperature deviation, caused by the temperature characteristics of the switching device can be compensated. One concept is to use a device of the identical type of the switching device to produce a temperature dependent signal and feed it as compensating voltage into the output reference point of the translinear amplifier. This will mirror the exact equivalent of the temperature error into the switching control signal and compensate its temperature error. Details of a possible implementation are provided in the related patent application US Serial No. 10/676919.

Even further, a specific non-linear characteristic of the tuning voltage to capacitance relation can be achieved by dimensioning the relation between said tuning voltage and said threshold points as desired. In one proposed solution, the individual steps of the reference resistor chain will be dimensioned to the desired nonlinear curve, for example when the steps between the threshold points, where the next capacitor starts to be switched on, are narrower in one area than in other areas, more capacitors

start to be switched in parallel and a steeper change of total capacitance can be achieved.

Please replace the forth paragraph beginning at page 8 with the following amended paragraph:

In accordance with the objectives of this invention, a method to control the capacitance of a variable capacitor in a strictly linear mode through a tuning voltage and to achieve a high Q-factor at the same time generate, is achieved. One method is to switch a variable number of capacitors in parallel, where only one is in the ~~active~~ steady transition phase of being switched on (or off) in a ~~continual~~ steady progressing mode (i.e. the effective capacitance being ramped-up or ramped-down). All other capacitors of a larger number of capacitors are either already fully switched on or are still complete switched off. One key method is to linearly control the switching function for each of said ~~continual~~ switching devices, when said switching device is ~~in its dedicated active working area~~ in an ~~linear~~ analog mode~~,~~ within the steady transition phase but to change the signal abrupt, as soon as the control signal for said switching function leaves its ~~dedicated active working area~~ steady transition area. One method drives said switching device to a fully-on status, when said switching device is outside its ~~dedicated active working area~~ steady transition area on the lower resistance side. A similar method drives said switching device to a fully-off status, when said switching device is beyond its ~~dedicated active working area~~ steady transition area on the higher resistance side. A further method amplifies, by ~~the means of~~ a translinear amplifier, the difference of the capacitance tuning voltage and the reference voltage of each amplifier stage, producing the linear control signal for said ~~continually~~ steady progressing switching operation. Another method generates a set of reference values, one for each of said amplifier

stages. Finally, the circuit supplies a tuning voltage, dedicated for the voltage controlled capacitance change, to all of said amplifier stages.

In the DESCRIPTION OF THE PREFERRED EMBODIMENTS, please replace the second and third paragraph beginning at page 13 with the following two amended paragraphs:

A discussion of the general principles of a voltage controlled variable capacitor with linear characteristic, formed of a larger number of fixed capacitor segments and a corresponding number of switching elements, using operational amplifiers is disclosed in the related US Patent Application ~~DS03-005A~~ Serial No. 10/764920, filed Jan. 26, 2004, the entire contents of which is incorporated herewith by reference.

Fig. 3 shows a principal circuit diagram of the referenced related patent application. A set of circuits to control the switching operation in a ramp-up/ramp-down manner, contains, typically besides other components, the set of operational amplifiers **Amp 1** to **Amp n** ~~are said operational amplifiers,~~. **Sw 1** to **Sw n** are ~~the~~ said switching devices and **Cap 1** to **Cap n** are said capacitors that will be switched in parallel. As an example, a resistor chain **R1** to **Rn**, or a similar circuit, produces a series of voltage references **Ref 1** to **Ref n** and each of said operational amplifiers compares the tuning voltage input with its dedicated reference voltage. The resulting variable capacitance is available at the output points **varCap**. As a minimum circuit implementation, a simple wire connection feeds the tuning voltage directly to the amplifier inputs.

Please add the following five paragraphs, after the third paragraph beginning at page 13.

As described in the related patent application (US Serial No. 10/764920, filed Jan. 26, 2004), within a set of small capacitors **Cap 1** to **Cap n**, one capacitor after the other is switched in parallel to change the total capacity. Each capacitor has its individual switching device **Sw 1** to **Sw n.** To achieve a linear capacitance change, said capacitors are not switched on one by one in digital steps, however each capacitor is switched on partially in a sliding operation, starting at low value (0 % of its capacitance) and ending with the fully switched on capacitor (100 % of its capacitance). To achieve said sliding switch operation, a typical implementation uses FET-transistors, one per capacitor. The switching operation of such FET-transistor can be divided into three phases: the fully-switched-off phase (the FET's RDS is very high), a steady ramp-up/ramp-down phase or steady transition phase, where the series resistance of said FET-transistor steadily changes from high to low values or vice versa, and the fully-switched-on phase (the FET's RDS is very low). By thoroughly controlling such switching device within said steady ramp-up/ramp-down or steady transition area, the capacitor in series with said switching device is effectively switched in parallel to the other capacitors with a well-controlled proportion between 0 % and 100 %. "Steady" is meant in the mathematical sense of being free of jumps or breaks. The limits of said steady ramp-up/ramp-down or steady transition area is distinguished by the points, where a further change of the controlling signal of the switch does not lead to further decrease or increase of the series resistance of said switching device (except for a small, negligible change).

In case a specific member of said switching devices is switched fully-on, the parallel connection of the capacitor (in series with said switching device in view) is fully effective (i.e. is effective to 100 %). If however a specific item of said switching devices

is switched fully-off, the parallel connection of the capacitor (in series with said switching device in view) is not effective at all (i.e. is effective to 0 %). While said switching device in view is within its steady ramp-up/ramp-down or steady transition phase, the capacitor may be effectively switched in parallel with any value between 0 % and 100 %. The effectiveness of the switching in parallel of said capacitor is well controlled through the amplifiers **Amp 1** to **Amp n** and the set of tuning and reference voltages, symbolized by the voltage dividing circuit of the resistor chain **R1** to **Rn**.

One can assume the steady transition area of RDS changing to be, for example, between the 2 % point and the 98 % point and define these limits as the "desired steady transition area".

The terms "steady ramp-up/ramp-down phase", "steady transition phase" or "steady transition area" and "steady switching transition phase" will be used throughout the document to define the phase of analog switching operation as opposed to a pure digital switching (pure on/off) operation. Outside said "steady transition area" the switching device is either fully on or fully off. As said before, "steady" is meant in the mathematical sense of being free of jumps or breaks. In the same sense, the term "continual" switching means the process of "steady ramp-up/ramp-down switching".

Therefore the switching device to switch on the capacitor, as used for the presented patent application is a "switching device with steady transition phase", in many cases shortly referenced herein as "switching device".

Please replace four paragraphs, starting at the forth paragraph beginning at page 13 with the following amended paragraphs:

A detailed view on the individual ramp-up functions at the switching transistor's gate, of the circuit according to Fig. 3, is shown in **Fig. 4a**. **Vg1** to **Vg7** are the gate voltage versus tuning voltage slope of the switching stages number 1 to 7 in this example. One can assume the ~~active~~ steady transition area of RDS changing to be, for example, between the 2 % point and the 98 % point and define these limits as the "desired steady transition area". All slopes of the individual gate voltages are strictly parallel. Threshold points **Th1** to **Th7** in **Fig. 11** are equally spaced (distances **d1** to **d7** in **Fig. 4a**). **Fig. 4b** visualizes the overlapping switching operations of just 2 adjacent stages of the circuit according to Fig. 3. **Overlap** is a measure, where **Vg2** just starts to switch on stage number 2 and where **Vg1** is still in the ~~active working range~~ steady transition area for stage number 1. Because said gate voltage versus tuning voltage slopes are all in parallel, all overlaps are the same.

According to the objectives of this invention, the operational amplifiers, within said set of circuits to control the switching operation in a ramp-up/ramp-down manner, as shown in **Fig. 3**, are replaced by translinear amplifiers. A single stage of said capacitor switching function is presented in **Fig. 5** and the total circuit schematic for multiple stages according to the proposed invention is shown in **Fig. 6**~~.~~, where a set of circuits to control the switching operation in a ramp-up/ramp-down manner, contains, typically besides other components, the set of translinear amplifiers Key advantage is the fact, that the voltage levels at the translinear amplifier inputs and at the translinear amplifier outputs are independent, only the differential voltage at the inputs and at the

outputs is important. ~~It~~ Said translinear amplifier works in this context as a level shifter. Such translinear amplifiers have typically a gain of 1.

The translinear amplifier in **Fig. 5** compares the differential voltage at its inputs **Vinp-5** and **Vinn-5** and, through various current mirroring techniques, provides the same differential voltage at its outputs **Voutp-5** and **Voutn-5**; i.e. the output difference of said amplifier strictly follows the difference at said amplifier inputs, independent of the absolute voltage level at the outputs. The translinear amplifier then drives said current switching device **N1-5** with the gate voltage **Vg-5** to ~~linearly~~ switch on said individual small capacitor **Cap-5** in the proposed steady ramp-up/ramp-down manner.

Within a chain of said translinear amplifiers, each one can operate at a different absolute voltage level at their input and work independent at another output level. In this way the network to generate the reference voltages can be optimized independently for each stage, because the voltage level best suitable for the control operation of each switching transistor can be freely selected. In the circuit shown in **Fig. 6** as an example, the reference voltages are produced in a simple chain of resistors. The translinear amplifiers **Tr.Amp 1** to **Tr.Amp n** can adjust between said input reference voltage levels **Ref-in 1** to **Ref-in n** and the output reference levels **Ref-out-1** to **Ref-out-n**. Said translinear amplifiers then control the switching transistors **Sw 1** to **Sw n**, which in turn ~~linearly~~ switch on the individual small capacitors **Cap 1** to **Cap n** in the proposed steady ramp-up/ramp-down manner.

Please add the following paragraph after the second full paragraph, beginning at page 15:

There are various techniques for a circuit to generate a set of reference values and provide the threshold points to each of said amplifier stages. And there are various techniques for a circuit to provide a signal, dependent on the tuning voltage, dedicated for the voltage controlled capacitance change, to all of said amplifier stages. As shown in Fig. 6 and Fig. 9, one solution for said circuit to generate a set of reference values is a simple resistor chain, and a possible and minimal solution for such circuit to provide the threshold points to each of said amplifier stages and for such circuit to provide a signal, dependent on the tuning voltage, dedicated for the voltage controlled capacitance change, to all of said amplifier stages is to connect said reference points and said tuning voltage with simple wire connections to the appropriate input lines of said translinear inputs.

Please replace two paragraphs, starting at the second paragraph beginning at page 15 with the following amended paragraphs:

Another key point of the invention is the implementation of a signal-limiting function at both ends of the ~~active~~ steady switching ~~operating~~ transition area. As long as the switching transistor is kept within its ~~active switching mode~~ steady transition phase (RDS changing mode) the resistance of the transistor linearly follows the input difference of said translinear amplifier. Once the signal controlling the switching device leaves the ~~dedicated active~~ desired steady transition area, the signal condition is now changed abrupt by the signal limiting circuit. **Fig. 7** visualizes this effect. The purpose is to overdrive said switching device to a fully-on state, when said switching device is outside its ~~dedicated active working~~ desired steady transition area on the lower resistance side and to overdrive said switching device to a fully-off status, when said switching device is beyond its ~~dedicated active working~~ steady transition area on the

higher resistance side. Additional circuit elements, implementing said signal-limiting function, drive said switching transistor either into ~~its fully-on state~~ deep saturation (RDSon going to 0) or drive it into its ~~fully-~~ extreme off state (RDSoff going very high) as soon as said switching device falls outside ~~its dedicated active working~~ said desired steady transition area. Such signal-limiting function could, according to the invention, be implemented within said translinear amplifier circuit, as it is shown in **Fig. 7** of the referenced patent application US Serial No. 10/676919, filed Oct. 1, 2003. ~~It~~ Said signal-limiting function could however be implemented as separate circuit external to said translinear amplifier as well.

Fig. 7 of the instant document visualizes the idea of sharply cutting off said signal controlling the switching device as soon as the Gate **Control Voltage Vg-7** leaves the ~~dedicated active~~ desired steady transition area, when the **Tuning Voltage Vctl** changes. For example, beyond the 98 % on-point, said signal **Vg-7** controlling the switching device rises sharply and below the 2 % off-point said signal **Vg-7** controlling the switching device is driven to rapidly switch-off. **Fig. 8** presents the same behavior as Fig. 7 for a larger number of said capacitor switching stages. **Th1** to **Thn** are the selected threshold points for said switching to occur. **d1** to **dn** are the distances of said threshold points, that normally are dimensioned to equal distance.

Please replace the third paragraph beginning at page 17 and the next two paragraphs with the following three amended paragraphs:

Typically, it would be desirable to achieve a linear relation between the tuning voltage and the capacitor variation, i.e. in a strictly linear mode. Then the reference voltages to compare with the tuning voltage, would normally be equally spaced. To achieve a steady, but predefined non-linear relation instead, other reference voltage

steps for said threshold points could also be selected, like spacing along a parabolic curve. Similar, the tuning voltage could be split into a multiple of tuning signals to feed them to the translinear amplifier inputs. Depending on the technique to implement the reference values defining said threshold points for each of the amplifiers within said translinear amplifier chain, ~~even~~ specific nonlinear relations of capacitance change versus tuning voltage can be constructed. The concept of said non-linear relation is demonstrated in **Fig. 12**, with **Curve A** and **Curve B** as examples.

In accordance with the objectives of this invention, a set of individual capacitors is implemented. Such capacitors could be ~~discrete~~ metal or polymer capacitors, eventually mounted or fabricated on a common planar carrier or they could be integrated on a semiconductor substrate. The advantage of a capacitor not being of the junction (diode) type capacitor is the invariance due to voltage or temperature at the capacitor. The switching device is typically a FET transistor, which could be for example a P-MOS or N-MOS junction FET or a CMOS FET. In the case complementary components are used all voltage levels would just be inverted without changing the principals of operation.

The method to achieve the objectives of this invention is illustrated in **Fig. 13**. First **(80)**, it starts with just the first capacitor, i.e. the count n=1 **(81)**. When the tuning voltage is rising **(82)** or is high enough **(83)**, the amplifier ramps up **(85)** and the switching device linearly switches on capacitor element n **(87)**. If the tuning voltage continues to rise **(90)** the amplifier continues to ramp up **(91)**. If however the tuning voltage turns down **(90)**, the amplifier will ramp down as well **(92)**. Once the tuning voltage reaches the upper limit of the ~~active switching~~ steady transition area **(95)**, the

switching device of stage n is fully switched on **(97)** and the process continues with the next step n = n + 1 **(99)(101)**. Depending on the direction of continued voltage change **(103)** it continues to ramp up or down. In case tuning voltage is lower than maximum for stage n **(84)**, the amplifier ramps down **(86)** and the switching device linearly switches ~~on~~ off capacitor element n **(88)**. Once the tuning voltage reaches the lower limit of the ~~active switching~~ steady transition area **(96)**, the switching device of stage n is fully switched ~~on~~ off **(98)** and the process continues with the next step n = n ~~+~~- 1 **(100)(102)**. Again, depending on the direction of continued voltage change **(103)** it continues to ramp up or down and restarts at **(82)**.